Prototype Parking Metering System—Phase 2

Project Plan

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List of Symbols and Definitions

A

Assembly language
A low-level computer language that consists of mnemonic codes and symbolic addresses corresponding to machine-language instructions

B

C

C
A high-level object-oriented programming language

C#
An object-oriented programming language based on the design principles of Java

D

E

F

G

H

J

Java
A high-level object-oriented programming language that allows small application programs to be downloaded from a server to a client along with the data that each program processes (developed by Sun Microsystems)

K

L

LCD
Liquid crystal display, a low-power digital display that uses liquid crystal cells that change reflectivity in an applied electronic field

M

Motherboard
For this project, it is a main circuit board of the embedded computer through which all signals are directed.

MySQL
MySQL is a fast-relational database manager. A database manager enables adding, retrieving, and processing information stored in a database. The relational aspect of MySQL means that data is stored in separate tables rather than one large table. Relations between each table can be established and information can be retrieved using structured query language (SQL).

N

O

P
Q

R

RAM
Random-Access Memory, the primary working memory in a computer used for the temporary storage of programs and data and in which the data can be accessed directly and modified

S

SQL
A standardized language that approximates the structure of natural English for obtaining information from databases

T

U

USB
Universal Serial Bus, a plug-and-play interface between a computer and peripheral devices, such as printers, modems, and keyboards

V

Visual Basic
A programming language and environment developed by Microsoft based on the BASIC language using graphical programming environment and a paint metaphor for developing user interfaces.

W

Wired Ethernet
A trademark for a system for exchanging messages between computers on a local area network using wired coaxial, fiber optic, or twisted-pair cables

X

Y

Z

Abstract

There are several pay-for-parking lots on the Iowa State campus managed by the Department of Public Safety (DPS). Currently, two of these lots are controlled by multi-space parking meter systems located near the lots. Several undesirable aspects of these units have left DPS searching for a better solution. This project will provide a solution by developing a multi-space meter system that provides the same functionalities as the current units, as well as adding new functions. The developed system will be more cost-effective, will be easier to use for people parking in the lots, and will make management of the lots more straightforward and more effective for DPS. This will make for a better experience for those using the system and will allow DPS to focus resources on other more pressing issues.

Acknowledgement

The team would like to acknowledge the following people for their contributions, both financially and intellectually, to the project: Doug Houghton, Captain, Department of Public Safety, Iowa State University. We would also like to thank the course instructor and project advisors, Dr. John W. Lamont and Professor Ralph Patterson III, for their guidance and advice regarding the project.

1. Problem Statement

The following sections will provide a general overview of the problem that this project seeks to address, as well as the proposed method of solving it.

1.1 General Problem Statement

At Iowa State University, as at other colleges around the United States, many issues arise concerning the availability of parking on or near campus. This has led to the development of several pay-for-parking lots on the Iowa State campus. Currently, use of these lots is controlled through centralized units that are able to monitor multiple spaces at once. This provides some advantages over traditional parking meters from an administrative standpoint, e.g. money can be collected at once from a central location.

However, while the current system currently has some benefits, there is still much left to be desired. The fact that the units cannot communicate with one another means that if a space is paid for on one machine, time can only be added later to that same exact machine. Also, when the lot is checked for offenders, each machine must be queried individually, which increases the time to check the lot. Lastly, this has implications for robustness. If one unit is disabled, all the data stored there is lost.

Another undesirable aspect of the current system is that the units are very hard to program. DPS would like to be able to set the hourly rates of the lots, as well as program in university holidays. In the current system, doing so requires a specialist. This process is both expensive and time consuming.

The project will be achieved by utilizing the efforts of two teams, May 04-02 and Dec 04-02. May 04-02 will be responsible for the slave units, while Dec 04-02 will be responsible for the master unit.

1.2 General Solution Approach

The solution proposed by this project is to provide a system to monitor the pay-for-parking lots that will have all the benefits of the current system as well as to improve on its negative aspects. The system will be more user-friendly, more cost-effective, more durable, and easier to maintain. In this solution, control of the parking lots will be implemented with several, multi-space, communicating units.

Because the units will be able to communicate, users of the lot may add time via any machine. Also, DPS will only have to query one machine to receive a complete list of lot activity. Lastly, this feature, combined with a redundant central processor and memory, will greatly increase the robustness of the system.

The new units will also have easier to use interfaces. This will allow DPS the ability to easily program in rate changes and holidays. This will also make it easier for people parking in the lots to utilize the system.

Lastly, the unit will be implemented with standard off the shelf computer hardware. This will decrease the cost to the University, both in initial cost and in maintenance cost.

2. Operating Environment

The designed units will be located outdoors, and thus must operate in a large range of temperatures as well as withstand the rain, snow, and other weather conditions present in Ames, Iowa. The system will be used on a regular basis, and thus must be designed to withstand extended use. Lastly, the units will be located on a college campus, and thus must be resistant to attempts at vandalism.

3. Intended Users

The users of this system fall into two main groups, users of the lots, and administrators of the lots.

The first group is made up of the people that park in the lots. This group includes (but is not limited to):

- College students at Iowa State University
- Faculty and staff of Iowa State University
- Visitors to the Iowa State campus

The second group is made up of those that monitor the parking lots, i.e. the Iowa State University Department of Public Safety employees.

4. Intended Uses

The system will have two main categories of uses, separated by the two groups of users (see above).

For the people who park in the lots, the system will:

- Allow parking spaces to be paid for, either by first selecting an amount of time, or by simply putting money in.
- Allow time to be added to any parking space from any unit in that lot.
- Provide a hard-copy receipt to the user if desired.

For the Department of Public Safety, the system will:

- Allow DPS to monitor and enforce the paid usage of the parking lots.
- Allow DPS to gather parking lot usage statistics.
- Allow DPS to change hourly rates and set holidays.

5. Assumptions

- The lot size will be equal to or less than 1000 spaces.
- No change will be returned to users.
- Power will be provided to the units, excepting power outages.
- The units will accept only dimes, nickels, and quarters as payment.

6. Limitations

- The time available to complete the project is limited.
- The unit must be weatherproof and theft-proof.
- The main processing unit must consist of two redundant processors.
- The main processing unit must have redundant storage.
- The user interface will be compact and user-friendly.
- Backup batteries must be able to allow the machine to run for four hours in the event AC electricity is unavailable.
- The system must provide all of the capabilities of the current system.
- DPS must be able to change rates and holidays without outside assistance.
- The units must allow users to add time to their current amount of time.

- The system must provide information on current stall payment status (paid or unpaid) for DPS enforcement.
- The system must accommodate time of day and holiday rates.
- The unit must have a receipt printer which will print receipts upon request.

7. Expected End Product and Other Deliverables

The end products of this project will be a prototype multi-space parking meter system, a user manual, and a technical specification. These deliverables are described below:

- Multi-space parking meter system

  The system will consist of a set of units configured to communicate with each other and able accommodate a lot size of up to 1000 parking spaces. The master unit will store all of the lot information, and the slave unit(s) will offer the same user interface but will use data from the master unit. The system will allow patrons of the lot to pay for parking, and allow DPS to monitor the usage and enforcement of the lot.

- User Manual

  The user manual will be a document describing the operation of the machines, in a non-technical manner that can be understood by any user of the system. These operations described in the manual include monitoring occupancy, making rate changes, and enforcement functions. A preliminary manual will be delivered when the system becomes ready for testing, and a final draft will be delivered in December of 2004.

- Technical Specification

  The technical specification document will be a document describing the technical specifications of both the hardware and software running on the master and slave units. This document not designed for common users, but instead as a resource for future designers of this system. The technical specification of the system will be delivered in December of 2004.

8. Proposed Approach

This section shall explain the planned method of completing the project.

8.1 Functional Requirements

The following functions shall be required to successfully complete the project.

- Accepts client input/output

  The system will connect to a remote computer using a USB connection. The system will allow DPS to change hourly rates, time of day rates, holiday rates, or modify any code that is installed on the master unit.

- Manages parking space availability

  The system will keep track of which parking spaces are currently paid for and ending time.

- Communication functionality

  The system will allow for communication between interfaces using Ethernet connection.

8.2 Constraints Considerations

The project shall run with in the following constraints.

- Weather resistance

  The system must be able to withstand all weather conditions an outdoor system may experience on the Iowa State University campus. These include extremes of temperature and precipitation as well as severe winds and associated debris.

- Durability

  The system must be durable, long lasting, and secure. If the unit is built above ground, it must be able to withstand theft, vandalism, corrosion, and minor collisions with vehicles. If buried, it must be able to withstand theft, vandalism, and ground moisture.

- Power requirements

  The master/slave system must be run off standard 110 AC power as well as a battery backup.

- Hardware requirements

  The master system must use a board with redundant processing and storing capabilities to decrease chances of failure.

- Connectivity requirements

  The master/slave system must be able to complete all necessary communications over a standardized Ethernet interface.

- Machine size requirements

  The control hardware will be placed inside one of the slave units, so it must be of a size that facilitates installation, maintenance, and use. The size of the machine must also be sufficiently large so as to allow for the inclusion of all necessary internal components.

8.3 Technology Considerations

The following technologies shall be considered in the implementation of the end-product.

- Master system hardware using dual processor-based system

  A system of this type utilizing two separate processors would allow for backing up a processor if one were to fail. It has redundant capability to store data to two sets of memory. If one processor were to fail, the second processor would takeover automatically where the other quit. This helps alleviate downtime so the master control unit can process parking locations and continue to accept money.

- Programming language
  - Assembly

    The use of assembly would allow for precise control over memory usage and data handling. It would make for an arduous development process, however.

  - MySQL

    The use of MySQL would allow for easy creation of the central database and integration with Windows XP operating system.

  - C/C#

    The use of C/C# would allow for the creation of a modular, robust, and easily modifiable software product.

  - Visual Basic.Net

    The use of Visual Basic.Net would allow for easy graphical user interface.

- Communications hardware using wired Ethernet

  A system of this type would allow for a more reliable communication medium and much faster than many other available technologies.

8.4 Technical Approach Considerations

To successfully create a multiple space parking meter system, two main components will need to be implemented: the master unit's hardware and the master unit's software. The hardware for the unit must meet the needs of the client. As such, the approach under consideration involves the use of off the shelf x86 dual processor-based hardware. This system would use redundant processing and storing technology, designed for the desktop and server market. A system of this type would allow for increased modularity and reliability, easier software design and implementation, components of a more standardized nature, easier maintenance and better expandability.

The unit requires a robust and feature-filled software package. To meet this need, a technical approach involves the use of C/C# for the creation of software and using Windows XP as an operating system. This approach would make for a modular, robust, and easily modified software product. The project team has extensive experience with this language, so there would be a rapid development process. MySQL is being considered as a language to create the database and should work well with the Windows XP operating system.

8.5 Testing Requirements Considerations

The following is a definition of the methodologies and acceptance criteria to be used in the testing of the intermediate and end-products resulting from this project.

- Testing of hardware
    - The communications hardware needs to be able to operate properly in the wide range of temperatures and other environmental variables discussed above, communicating without error and with sufficient speed for the application.
    - The hardware as a whole will be deemed acceptable if it all operates properly under the aforementioned conditions. If any one type of hardware fails the tests, alternative hardware must be selected to replace this undesirable hardware.
- Testing of software
    - The software needs to be tested to ensure that it functions as desired and is sufficiently robust to withstand daily use.
    - The software will be deemed acceptable if it performs all of the desired functions without error and an uptime of seven days is observed.

8.6 Security Considerations

Security is always a concern when dealing with a system involving monetary transactions. As data will be transmitted across an Ethernet link, an encryption protocol may be needed. Ethernet was selected over wireless for numerous reasons, one of them being data security. The end-product must also be physically secure. Physical security will be in the form of a secure enclosure designed to withstand vandalism, theft, and collision with a motor vehicle. This enclosure will have locking panels which give access to the electronic hardware as well as the coin box. To make changes to the rate database one must have a key for the physical lock and the computer password.

8.7 Safety Considerations

This device poses few safety risks. However, the device does contain electrical components, so electrical safety must be addressed throughout the design, construction, and use of the product.

8.8 Intellectual Property Considerations

This project introduces significant differences in design and construction when compared to similar systems on the market. This should eliminate any trademark infringement issues. Previous related works that are consulted in the course of this project will be duly acknowledged. Any intellectual property that results from this project will be the property of the team members and the Iowa State University Department of Public Safety.

8.9 Commercialization Considerations

When compared to popular models currently on the market, the system in development adds features and functionality while drastically decreasing cost. As a result, the probability of successfully marketing a product based upon the system currently in development is high.

8.10 Possible Risks and Risk Management

A number of potential risks have been identified:

- Loss of a team member

  In the event a team member is lost, the work assigned to that member will be redistributed. This risk will be mitigated by implementing a “buddy system” where at least two members of the group undertake an assigned task.

- Lack of technical expertise

  A large loss of productivity may be incurred when team members spend time gaining familiarity with a new technical aspect. This particular risk is pre-anticipated and its effects are mitigated by appropriately allocating time.

- Equipment damage

  Unintended damage to project hardware components will take a toll in both time and replacements costs. This risk will be mitigated by properly handling and storing all equipment.

- Inadequate budget

  If the amount of funding for the designed project can not be attained, the original plan will be revised. Solutions could include looking for donations, removing features, or accepting hardware of lower quality.

- Equipment availability

  Essential hardware may not be available for some unforeseen reason. Many of the items used are produced in low volume and are not always readily available. This risk will be mitigated by thoroughly researching hardware selections. The hardware will be selected as modular as possible, so no one specific component is irreplaceable.

8.11 Project Proposed Milestones and Evaluation Criteria

- Project definition

  Proper completion of this milestone will be the definition of a problem area, intended uses and users, design assumptions, limitations and approaches, project resource requirements, tracking and monitoring procedures, and evaluation criteria.

- Research and technology

  The information gained by research into the advantages and disadvantages of hardware and software selections will be used to select a suitable selection of hardware and software elements to construct the parking meter system.

- Design

  Proper completion of this milestone will result in the creation of a device design that meets the needs of the client and gets the approval of the faculty advisors. This will include the selection of hardware and software that can be acquired for a prototype demonstration of concept.

- Implementation

  The actual software coding of the parking meter system includes generating the code for various subsystems, including communication between devices, a database of rates, and generating statistical data.

- Testing

  Verifying the code was correctly implemented, and that it meets the client's needs. This includes testing performance of the software as well as correctness of the code. The system will be tested in lab as well as in the field. As the system deals with monetary exchange, extensive testing will be required.

- Demonstration

  Proper completion of this milestone will be the successful demonstration of the fully-functional multi-space parking meter prototype unit. Product demos will be constructed during the design phase for validation purposes.

Table 1: Project Milestones and Overall Importance

Milestone	Importance	
	Relative	Percentage
Problem Definition	High	21.43
Research and technology	High	21.43
Design	Medium	14.29
Implementation	High	21.43
Testing	Medium	14.29
Demonstration	Low	7.14
TOTAL		100%

Table 2: Milestone Evaluation	
Evaluation Result	**Numerical Score**
Exceeded/Met	100%
Partially met	75%
Did not meet	50%
Did not attempt	0%

8.12 Project Proposed Tracking Procedures

The consistent flow of information regarding the status of the project is essential. The information will be provided in the form of status reports, schedule updates, and financial analysis.

The project plan contains a set of planned elements that are to be tracked and monitored throughout the duration of the project. The tracking activities include:

- Weekly status reports regarding current and planned activities will be sent out to the client, advisors and team members.

- The planned schedule will be compared to the actual progress to determine the current project status. If the actual progress has not met the planned progress, steps will be taken to determine the cause of the delay, the impact on the overall schedule, and to identify corrective measures to compensate for schedule variance.

- The planned budget will be compared to the actual expenditure by analyzing expenditures to date and estimating cost to and at completion.

These tracking measures will be used to provide critical project information without becoming an excessive burden. Microsoft Project will be used to help automate the tracking procedures and project management.

9. Statement of Work

The following is a formal statement of work containing a hieratical list of major tasks and subtasks containing their objectives, approaches, and results.

Task 1 – Problem definition

- Objective
  Define the problem thoroughly, taking into consideration all possible users, uses, technological approaches, and design approaches to reduce cost and time.
- Approach
  Gather complete information about the problem from the client, faculty advisors, and potential users of the system.
- Result
  Complete problem definition containing uses, users, assumptions, limitations, functional requirements, management procedures, and success evaluation criteria.

Task 2 – Research and Technology

- Objective
  Research, select, and obtain the hardware and software that will best produce completion of the project.
- Approach
  Consult sources and professionals to find appropriate hardware and software that meets functional requirements, cost, robustness, and availability.
- Result
  Hardware and software will be selected and obtained that meets the project functional requirements, robustness, has current availability, and is within budget.

Task 3 – Design

- Objective
  Define and describe the design that will produce the successful end product within budget and on time.
- Approach
  Use sound design principles to create a complete and functional design.
- Result
  A project design that is complete and well defined so that there is no design issues during its implementation.

Task 4 – Implementation

- Objective
  Implement the project that is described by the design requirements.
- Approach
  Develop, test, and install software on the assembled hardware given by the design requirements.
- Result
  A functioning product that meets the design requirements, specifications and the clients needs.

Task 5 – Testing

- Objective
  Verify that the software and hardware works correctly as described by the design requirements.
- Approach
  Test all functionality of the software and hardware to make sure there is no failure that would cause the system to become not functional or in an undefined state.
- Result
  The system is verified to meet the design requirements.

Task 6 – Demonstration

- Objective
  Create and perform a demonstration that shows the successful implementation of the project.
- Approach
  Examine the needs of the demonstration and plan the demonstration to meet those needs.
- Result
  The demonstration will show successful implementation of the project by showing its functionality and robustness. The demonstration will verify that the project met all of its requirements.

10. Estimated Resources and Schedule

This section describes the current estimates of resource requirements and the project schedules. Table 3 shows the projected personnel effort of individual team members for each of the following tasks:

- Task 1 — Project definition
- Task 2 — Research and technology
- Task 3 — Design
- Task 4 — Implementation
- Task 5 — Testing/verification
- Task 6 — Demonstration
- Overhead — Weekly meetings, discussions, travel time, and other misc. items

Table 3: Personnel Effort Requirements

Personnel Name	Hours							
	Task 1	**Task 2**	**Task 3**	**Task 4**	**Task 5**	**Task 6**	**Overhead**	**TOTAL**
Joe Reinsma	11	12	36	76	16	13	45	209
Mikel Bezdek	10	10	31	76	17	12	44	205
John Goldbach	12	10	34	78	16	12	44	206
Andrew Ross	12	10	30	74	16	12	40	199
Irsan Halim	10	10	29	77	15	12	45	201
TOTAL	55	52	160	387	82	61	223	1020

Table 4 and Table 5 summarize the estimated financial cost of equipments and other resource requirements to design a working prototype.

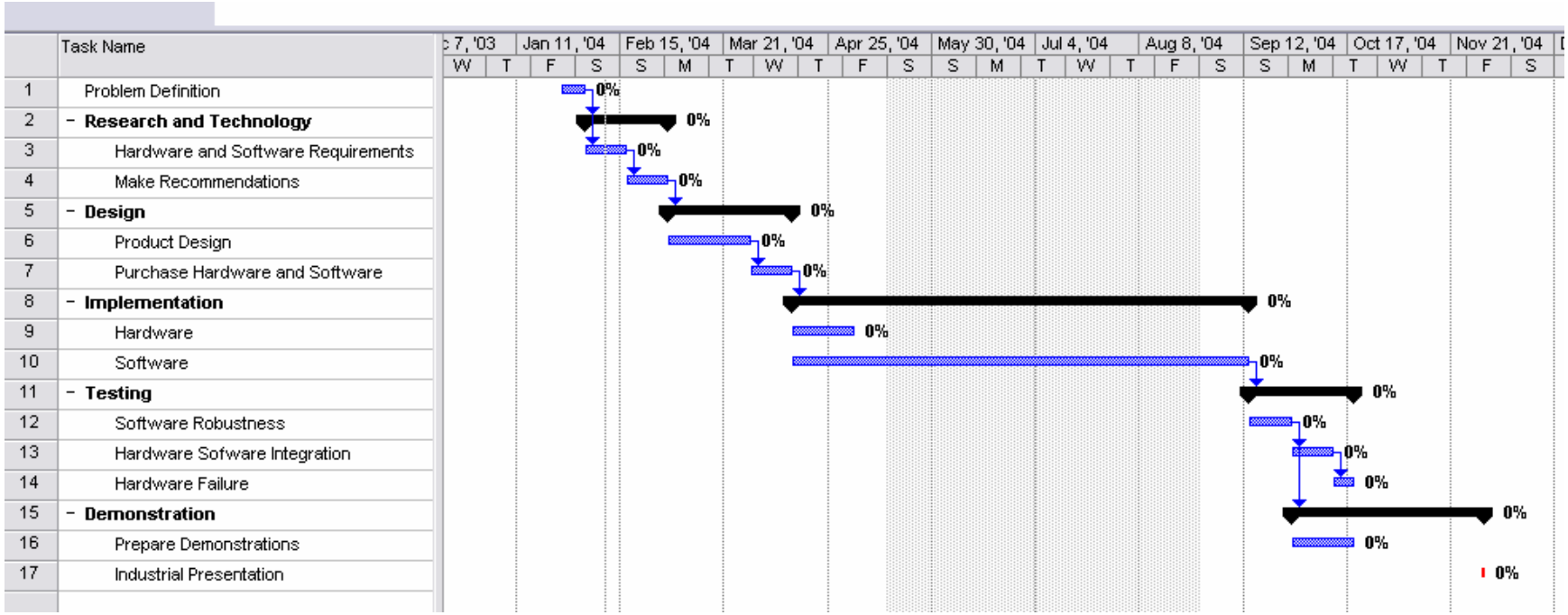
Table 4 : Other Resource Requirements		
Item	**Team Hours**	**Cost**
Motherboard/Processor$_1$	0	$150
RAM$_1$	0	$50
Storage$_1$	0	$200
Motherboard/Processor$_2$	0	$150
RAM$_2$	0	$50
Storage$_2$	0	$200
LCD	0	$75
Keypad	0	$100
Misc. Buttons	0	$50
Printer Controller	0	$120
Ethernet Switch	0	$57
UPS Battery Backup Unit	0	$100
Housing	0	$100
Project Poster	10	$50
TOTAL	10	$1452

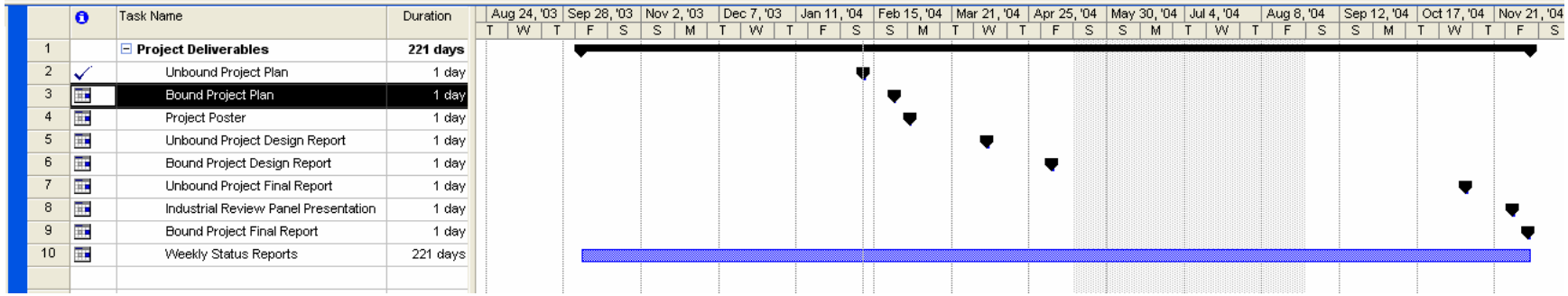
Table 5 : Financial Requirements	
Item	**Cost**
Parts and materials	
Motherboard/Processor$_1$	$150
RAM$_1$	$50
Storage$_1$	$200
Motherboard/Processor$_2$	$150
RAM$_2$	$50
Storage$_2$	$200
LCD	$75
Keypad	$100
Misc. Buttons	$50
Printer Interface	$120
Ethernet Switch	$57
UPS Battery Backup Unit	$100
Housing	$100
Project Poster	$50
Services	
Shipping and handling	$50
Binding	$30
TOTAL (w/o Labor)	$1532
Labor ($10.50 / hour)	
Joe Reinsma	$2331
Mike Bezdek	$2100
John Goldbach	$2163
Andrew Ross	$2037
Irsan Halim	$2079
TOTAL (w/ Labor)	$12062

11. Schedule

The following section includes a Gantt chart detailing the projected schedule of tasks. The illustrated calendar will span the full length of the project, which is two semester long. The timelines for the various tasks are based on the team's best estimates of time requirements, as well as the Senior Design class and deliverable schedules. The team will adhere to the schedule to the best of its ability in order to keep the project on task.

Project Schedule




Task Name
Duration
1 Project Deliverables 221 days
2 Unbound Project Plan 1 day
3 Bound Project Plan 1 day
4 Project Poster 1 day
5 Unbound Project Design Report 1 day
6 Bound Project Design Report 1 day
7 Unbound Project Final Report 1 day
8 Industrial Review Panel Presentation 1 day
9 Bound Project Final Report 1 day
10 Weekly Status Reports 221 days
Aug 24, '03
Sep 28, '03
Nov 2, '03
Dec 7, '03
Jan 11, '04
Feb 15, '04
Mar 21, '04
Apr 25, '04
May 30, '04
Jul 4, '04
Aug 8, '04
Sep 12, '04
Oct 17, '04
Nov 21, '04

12. Project Team Information

The following individuals are those directly involved in the definition, development, and implementation of this project.

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13. Closing Summary

The need for a powerful and easy to use, yet cost effective solution for managing vehicle parking on the campus of Iowa State University has never been greater. Solutions currently available are not feature rich enough, too difficult for easy use, or are too expensive. It is for these reasons that the University is commissioning the creation of the multiple space parking meter system described in this document. The system resulting from the work of this project team will exceed the University's current needs and will allow for easy modification in order that it may continue to meet the University's needs for years to come. This will result in increased revenues for the University, and will allow those managing parking to focus on other duties.

14. References

Prototype Parking Metering System May 04-02
10 February 2004
from http://sd.theotron5000.com/files/designdocument.pdf